

Sleep and arousal mechanism

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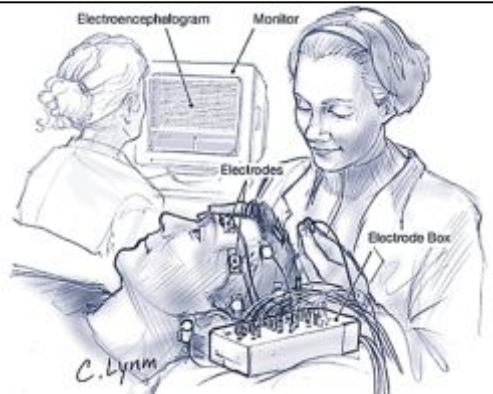
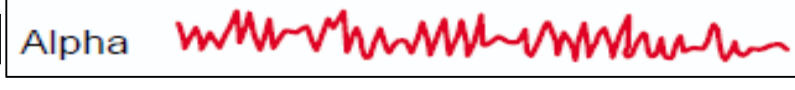
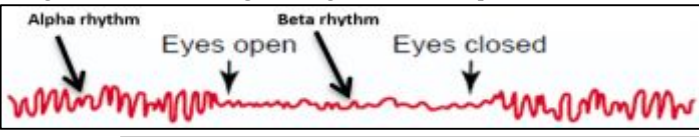
Introductory case:

A 60-year-old male experienced numerous episodes of a sudden loss of muscle tone and an irresistible urge to sleep in the middle of the afternoon. He was diagnosed with narcolepsy.

Learning objectives

1. Define: EEG, sleep, narcolepsy and somnambulism?
2. Describe: alpha, beta, theta, delta and gamma waves of electroencephalogram (EEG)?
3. Describe mechanism of seizures and epilepsy?
4. Explain the functions of the reticular activating system (RAS, reticular formation)?
5. Compare and contrast between Non REM (NREM) and REM sleep (types of sleep)?
6. Discuss the possible mechanisms of sleep?
7. Outline sleep disorders?

Electroencephalogram (EEG): (See table-1 and figures 1, 2, 3, 4, 5, 6 and 7)

Definition of EEG	It is a diagram that represents the record of the electrical activity (potential variations) that occurs in the brain in different conditions. NB: ➤ Electroencephalograph: it is the apparatus used in recording the electrical activity of the brain. ➤ Electroencephalography: it is the process of recording the electrical activity of the brain. ➤ Electrocorticogram: it is a diagram that is obtained if the recording electrodes are applied directly on the brain during neurosurgical operations. ➤ The EEG recorded from the scalp is a measure of the summation of dendritic postsynaptic potentials rather than action potentials. <i>Figure-1: Electroencephalography.</i> 
How EEG is recorded?	It is recorded by applying electrodes on the scalp.
EEG rhythms (waves)	EEG waves include: 1-Beta rhythm: - Frequency: 18-30 cycle/sec (Hertz, Hz). - Amplitude: 25 microvolts (μV). - Chief locality of recording: frontal and parietal lobes. - It is recorded in: alert conditions (with alpha rhythm in alpha block, see below). <i>Figure-2: Beta rhythm.</i>  2-Alpha (Berger) rhythm: - Frequency: 8- 13 cycle/sec (Hertz, Hz). - Amplitude: 50 microvolts (μV). - Chief locality of recording: occipital and parietal lobes. - It is recorded in: adults during complete rest with closed eyes (but, awake) i.e. with physical and mental rest. <i>Figure-3: Alpha rhythm.</i>  - Factors affecting alpha (Berger) rhythm: it is decreased in frequency by: Hypoglycemia. Hypothermia. Low adrenocortical hormones. High arterial CO₂ tension. So, hyperventilation causes disturbances in EEG. - Alpha block (dysynchronization): ➤ Definition: alpha rhythm is replaced by beta wave (rhythm). ➤ Recording conditions: during alert conditions e.g. solving mathematical problems. <i>Figure-4: Alpha block.</i>  3-Theta rhythm: - Frequency: 4-7 cycle/sec (Hertz, Hz). - Amplitude: 100- 150 microvolts (μV). - Chief locality of recording: temporal and parietal lobes. - It is recorded in: - In children during sleep. - In emotional stress in adults. - In brain disease. <i>Figure-5: Theta rhythm.</i>  4-Delta rhythm: - Frequency: 1-3 cycle/sec (Hertz, Hz). - Amplitude: 250- 300 microvolts (μV). - Chief locality of recording: All lobes of the cortex. <i>Figure-6: Delta rhythm.</i> 

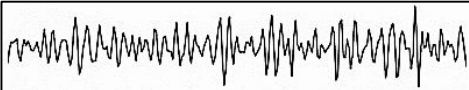
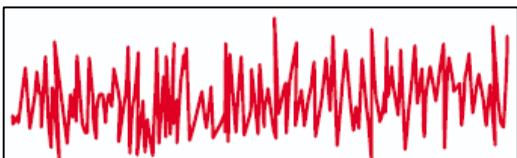
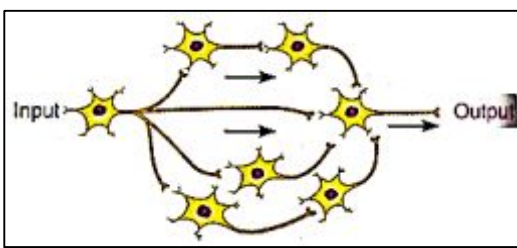
	d. <u>Delta rhythm</u> is recorded in: 1. <u>Deep sleep</u>. 2. <u>Deep anesthesia</u>. 3. <u>Coma</u>. NB: Delta rhythm is the <i>only</i> rhythm recorded if cerebral cortex is separated from thalamus. 5-Gamma rhythm (wave) in EEG: a. <u>Definition</u>: they are typically of a <u>high frequency and amplitude</u>. b. <u>Frequency</u>: 30-80 Hz (one of the fastest waves that reach all parts of the brain). c. It is recorded in: <u>geniuses</u> (normally, people do not produce these brain waves under normal circumstances). They are often seen when an individual is aroused and focuses attention on something. d. <u>Significance</u>: they give a chance for <u>better learning</u> since the brain is so super-active, people are able to learn faster (information is processed at a much higher rate).	 Figure-7: Gamma rhythm.
Importance (clinical uses) of EEG	1. <u>Localization of cortical areas</u>. 2. <u>Explanation of cortical state</u> in <u>sleep</u> and <u>wakefulness</u> (arousal state). 3. <u>Localization of disorders</u> of <u>conscious</u> state. 4. <u>When a collection of fluid overlies a portion of the cortex</u>, activity over this area may be damped. This fact may aid in diagnosing and localizing conditions such as <u>subdural hematomas</u>. 5. <u>It helps in determination of type of epilepsy</u>: a. <u>In grand mal epilepsy</u>: fast high voltage spike waves. b. <u>In petit mal epilepsy</u>: double wave (fast spike and slow flat).	

Table-1: Electroencephalogram (EEG).

Epilepsy: (See table-2 and figures 7, 8 and 9)

Definition	☞ It is uncontrolled excessive activity of either part or all of the central nervous system. NB: ☛ Seizure (convulsion): <u>paroxysmal</u> (attacks), <u>time-limited change in motor activity</u> and/or behavior that results from <u>abnormal electrical activity</u> in the brain. It occurs because of increased firing of neurons that are excitatory (e.g. release of glutamate) or decreased firing of neurons that are inhibitory (e.g. release GABA). ☛ Epilepsy: is present when <u>two or more unprovoked seizures</u> occur at an <u>interval greater than 24 hours apart</u>. ☛ Status epilepticus: a neurologic emergency in which the patient develops generalized or partial seizures, lasting for 30 minutes or longer (or a series of seizures in which the patient does not regain consciousness in between seizures).	
Types of epilepsy	I-Grand mal epilepsy: ☞ Duration of a grand mal seizure: from a few seconds to 4 minutes. ☞ Manifestations of grand mal epilepsy: 1. It is characterized by <u>extreme neuronal discharges in all areas of the brain</u> which are transmitted into the spinal cord, sometimes cause <u>generalized tonic seizures</u> of the entire body, followed toward the end of the attack by <u>alternating tonic and spasmodic muscle contractions</u> called tonic-clonic seizures. 2. The patient often <u>bites (or swallows) his tongue</u> and may have <u>difficulty breathing</u> (dyspnea), sometimes to the extent that <u>cyanosis</u> (bluish discoloration of skin and mucous membranes due to increased reduced hemoglobin) occurs. 3. Also, signals transmitted from the brain to the <u>viscera</u> frequently cause <u>urination</u> and <u>defecation</u>. 4. <u>Post seizure depression of the entire nervous system</u>: the person remains in <u>stupor</u> (surprise) for 1 to many minutes after the seizure attack is over, and then often remains severely fatigued and asleep for hours thereafter. ☞ EEG in grand mal epilepsy: shows <u>high-voltage, high-frequency discharges</u> occur over the entire cortex. ☞ Cause of extreme neuronal overactivity during a grand mal attack (mechanism): <u>massive simultaneous activation of many reverberating neuronal pathways</u> throughout the brain. ☞ Factors that stop the grand mal attack (after few minutes): a. <u>Neuronal fatigue</u>. b. <u>Active inhibition by inhibitory neurons</u> that have been activated by the attack.	 Figure-8: EEG in grand mal epilepsy.  Figure-9: Reverberating neural pathways.

II-Petit mal epilepsy:☞ **Manifestations:**

1. It is usually characterized by 3 to 30 seconds of unconsciousness (or diminished consciousness).
2. During that time, the person has twitch-like contractions of muscles usually in the head region, especially blinking of the eyes.
3. This is followed by return of consciousness and resumption of previous activities (absence syndrome or absence epilepsy).
4. The patient may have one such attack in many months or, in rare instances, may have a rapid series of attacks, one after the other.

☞ **EEG in a petit mal epilepsy:** shows a spike and dome pattern.☞ **Possible mechanism of a petit mal epilepsy:** oscillation of inhibitory thalamic reticular neurons (which are GABA producing neurons) and excitatory thalamo-cortical and cortico-thalamic neurons.

Figure-10: EEG in a petit mal epilepsy.

III-Focal epilepsy:

- ☞ **Site of lesion:** it can involve almost any local part of the brain, either localized regions of the cerebral cortex or deeper structures of both the cerebrum and brain stem.

Table-2: Epilepsy.

Reticular formation (RF): (See table-3 and figures 11, 12 and 13)

Functional structure of RF	☞ It consists of millions of neurons which spread along the mid-ventral part of the whole brainstem. ☞ It is corresponding to: the interneurons of the spinal cord, being continuous with them in the upper cervical segments, then, extending upward to the level of the intralaminar and nonspecific thalamic nuclei anastomosing with them, then, diffusing to nearly all areas of the cerebral cortex (forming RAS system). NB: Reticular activating system (RAS): it is a complex polysynaptic pathway that arises from the brainstem reticular formation and gives projections to the intralaminar and reticular nuclei of the thalamus which, in turn, project diffusely and nonspecifically to wide regions of the cerebral cortex.
Types of neurons in RF	I-Sensory neurons in RF: ☞ They are the largest in number but the smallest in size. ☞ They have short axons. ☞ They make many interconnections with each other. ☞ They are sites of convergence, divergence and formation of the reverberating circuits which enable RF to act as a link between lower and higher centers in the brain. ☞ They receive afferent connections from: a. All ascending tracts including auditory, olfactory, and visual pathways. b. Many higher centers including cerebral cortex, hypothalamus basal ganglia, cerebellum and vestibular apparatus. II-Motor neurons in RF: ☞ They are lesser in number but, larger in size. ☞ They have longer axons which form two distinct types of fibers: a. Ascending fibers: ➤ Connect with nonspecific thalamic nuclei and then diffuse to nearly all areas of cerebral cortex. ➤ This system is called reticular activating system (RAS). b. Descending fibers: reach AHCs (both alpha cells and gamma cells) at all levels of the spinal cord forming the reticulospinal tracts which regulate muscle tone. III-Specific centers in RF: ☞ Many neurons in RF collect and form specific centers, which have certain functions. ☞ Examples of specific centers: 1. Red nucleus.

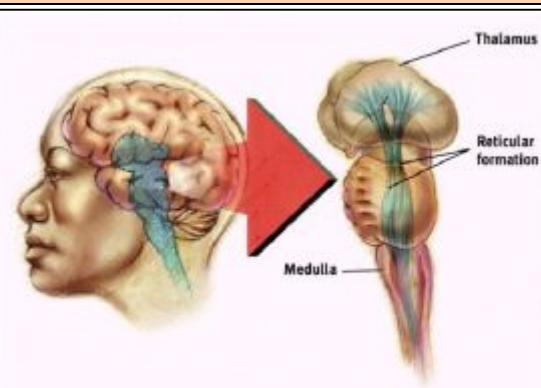


Figure-11: Reticular formation location.

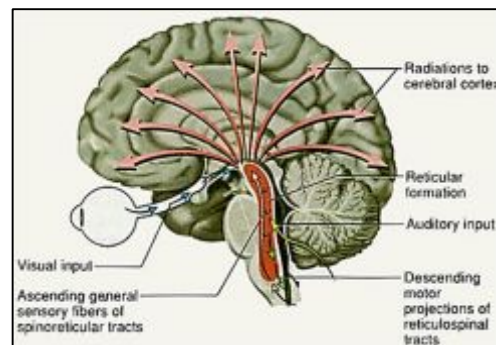


Figure-12: Reticular formation connections.

2. Olivary nuclei.
3. Vestibular nuclei.
4. Respiratory centers.
5. Cardiac centers.
6. Deglutition center.
7. Vomiting center.

IV-Neurotransmitter secreting neurons in RF:

☞ RF contains many neurons and their nerve fibers which secrete and form many chemical transmitters that regulate the chemistry of the brain.

☞ Examples of neurotransmitter secreting neurons in RF:

1. Serotonergic fibers.
2. Adrenergic fibers.
3. Dopaminergic fibers.

Functions of RF (and RAS system)

☞ They include:

1-RF acts as a link between higher centers in the brain and the lower centers in the spinal cord.

2-Role of RF in regulation of muscle tone:

A. Facilitatory (pontine) RF:

- ♦ It is the dorsolateral RF in the pons.
- ♦ It has its own intrinsic activity.
- ♦ It is stimulated by: area 4, neocerebellum and vestibular nucleus.
- ♦ It is inhibited by: suppressor cortical centers.
- ♦ It gives rise to ventral reticulospinal tract.
- ♦ It increases muscle tone.

B. Inhibitory (medullary) RF:

- ♦ It is the ventromedial RF in medulla.
- ♦ It has no intrinsic activity.
- ♦ It is stimulated by: the suppressor cortical areas, basal ganglia and paleocerebellum.
- ♦ It gives rise to lateral reticulospinal tract.
- ♦ It decreases muscle tone.

3-Regulation of autonomic functions: as many vital centers as respiratory, cardiovascular and vasomotor centers are parts of the RF.

4-Regulation of the arousal state: via the reticular activating system (RAS). (See below)

5-Regulation of brain chemistry: as it contains many neurons that secrete many chemical transmitters which regulate brain functions.

6-Pain perception and control: as the RF contains many opiate receptors and many neurons that secrete endogenous enkephalins and endorphins.

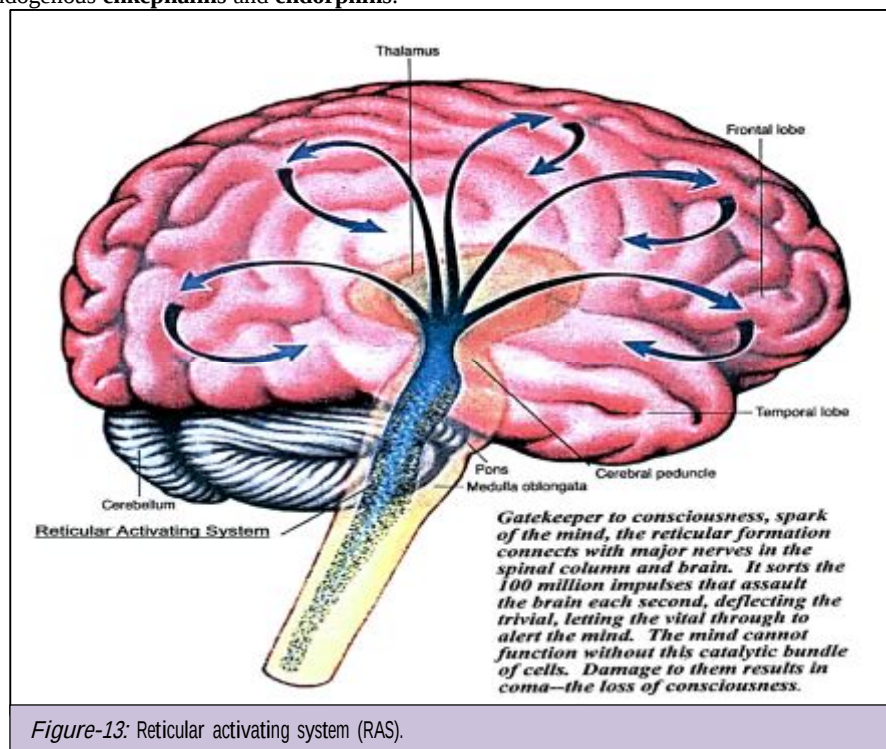


Figure-13: Reticular activating system (RAS).

Table-3: Reticular formation and RAS system.

Sleep: (See table-4 and figures 14, 15, 16, 17, 18 and 19)

Definition	☞ Sleep is a state of transient loss of consciousness from which person can be aroused by normal non harmful stimuli .
Normal sleep hours	☞ Adult persons : need from 7 - 9 hours of sleep every 24 hours. ☞ Newborns : need from 16-18 hours of sleep every 24 hours. ☞ Old persons : need less hours of sleep every 24 hours.
Importance of sleep	1. It restores both normal levels of activity and balance among the different parts of the neurons in the CNS. 2. Sleep is needed to maintain metabolic-caloric balance , thermal equilibrium, and immune competence. 3. It is necessary for learning and memory consolidation . (See higher brain function chapter) 4. Lack of sleep causes : a. The person to become irritable and even psychotic, with great loss of concentration and extreme fatigability . b. Marked increase in sympathetic activities all over the body. c. Disturbance in other body functions secondary to disturbance in their nervous control as digestion, absorption, hormone secretions, vasomotor and cardiovascular regulation.
Types (phases) of sleep	I-Slow wave (non-REM, NREM) sleep (SWS): 1. It represents most sleep during night. 2. It lasts about 80-90 minutes. 3. It occupies 75% of sleep time. 4. Its period increases when person has no desire to sleep. 5. No eye movements occur during it. 6. There is 30% reduction in cardiovascular and metabolic activities. 7. Dreams occur but are not remembered. 8. Brain waves are very slow (delta wave in deep sleep): a <i>theta</i> rhythm can be seen during stage 1 of sleep. Stage 2 is marked by the appearance of sleep spindles (waves of high frequency and amplitude) and occasional K complexes (largest normal wave recorded during sleep indicating suppression of cortical arousal and it is the sleep based memory consolidation). In stage 3, a <i>delta</i> rhythm is dominant. Maximum slowing with slow waves is seen in stage 4. (See sleep cycle below) 9. The person is easier to be aroused (awakened). 10. Muscle tone is slightly inhibited. 11. No abnormal muscle movements. 12. Brain is not active with diminish in its metabolism. 13. No penile erection in males. II-Rapid eye movement (REM, paradoxical) sleep: 1. It occurs in episodes during night. 2. It lasts only 15 minutes. 3. Occupies only 25% of sleep time. 4. Its period increases when the person is <i>very tired</i> and vice versa. 5. Characteristic rapid eye movements occur during it. 6. Heart rate, blood pressure and respiration become irregular and may increase. 7. Active dreams occur and are remembered. 8. Brain waves like a <i>wakefulness state</i> (low-voltage and high-frequency EEG). 9. Person difficult to be aroused. 10. Extreme inhibition of muscle tone due to increase activity of the inhibitory supra-spinal centers with increased activity of inhibitory (medullary) reticular formation. 11. Few irregular muscle movements. 12. Brain is highly active with increase in its metabolism 13. Erection in genital organs (even in children and clitoris in females). 14. It is called paradoxical sleep because of increased brain activities and brain metabolism during it.
Theories (possible mechanisms) of sleep	A-Passive theory of sleep: ☞ It states that: reticular activating system receives visual, auditory and tactile impulses from surroundings, then; it activates cerebral cortex causing a state of wakefulness (arousal). <i>Fatigue of these neural circuits</i> was thought to cause sleep until recovery occurs and so on. ☞ However, transection in brainstem in mid-pontine region leads to a brain that never goes to sleep, which indicates presence of other centers below mid pons that send impulses to higher centers causing sleep.

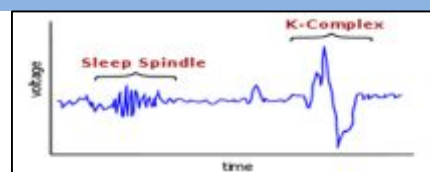


Figure-14: Sleep spindle and K-complex.

a *theta* rhythm can be seen during stage 1 of sleep. Stage 2 is marked by the appearance of **sleep spindles** (waves of high frequency and amplitude) and occasional **K complexes** (largest normal wave recorded during sleep indicating suppression of cortical arousal and it is the sleep based memory consolidation). In stage 3, a *delta* rhythm is dominant. Maximum slowing with slow waves is seen in stage 4. (See sleep cycle below)

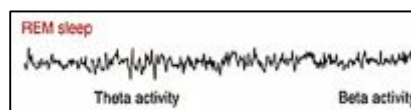


Figure-15: Brain waves during REM sleep.

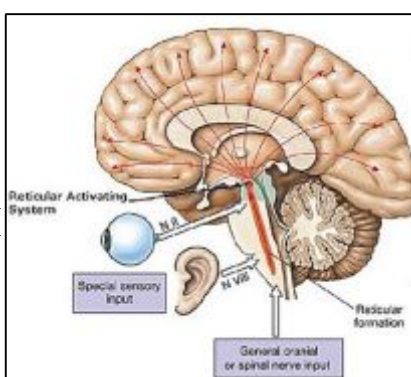


Figure-16: Passive theory of sleep.

B-Active theory of sleep:

☞ **It states that:** stimulation of certain areas in the central nervous system (CNS) produces sleep.

☞ **These areas include:**

1. *Raphe nuclei* in lower pons and medulla oblongata.
2. *Locus ceruleus* in the brainstem is considered as a center for REM sleep. Its neurons secrete norepinephrine.
3. *Nucleus of tractus solitaries*.
4. *Rostral part of the hypothalamus*.
5. *Some diffuse nuclei in thalamus*.

C-Metabolic theory of sleep:

☞ **It states that:** the prolonged wakefulness causes progressive accumulation of many metabolites (as muramyl peptide and serotonin, sleep factors) in brainstem and CSF, that when reach a certain concentration they produce sleep.

A sleep factor:

- ♦ **Nature:** serotonin.
- ♦ **Separated from:** brainstem of animals that were kept awake for days.
- ♦ **Its injection into:** third ventricle of normal animals caused immediate sleep.

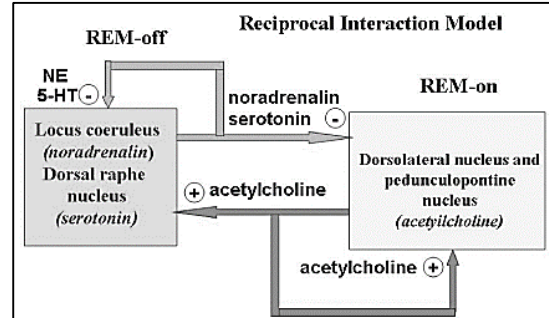
D-Positive feedback theory:

☞ **It states that:** there is a positive feedback between reticular formation and cerebral cortex. It explains sleep/wakefulness cycle (periodicity between sleep and wakefulness).

☞ **Mechanism:** when the sleeping centers are not active, the reticular activating system stimulates the cerebral cortex which in turn activates the reticular formation that reactivates the cerebral cortex and so...on. This keeps the state of wakefulness (arousal) till it becomes fatigued (or the sleeping centers become active).

Positive feedback mechanisms in the body:

1. Between cerebral cortex and the reticular formation i.e. wakefulness state.
2. Between estrogen and LH hormone i.e. LH surge and ovulation.
3. In labor, uterine contraction push head of baby to dilate the cervix which gives afferent impulses to sacral region causing more uterine contraction and so on.
4. Hyperthermia increases metabolism that causes hyperthermia and so on.
5. Platelet aggregation and blood clotting.
6. Sodium influx during action potential

**- Reciprocal Interaction Model**

Cholinergic REM-on cells and serotonergic-noradrenergic REM-off cells. During wakefulness, aminergic REM-off system is tonically activated, causing EEG desynchronization and inhibiting cholinergic REM-on cells. During REM sleep, aminergic REM-off cells are silenced and the cholinergic system, free from inhibitory influences, reaches its peak.

Figure-17: Mechanism of REM sleep.

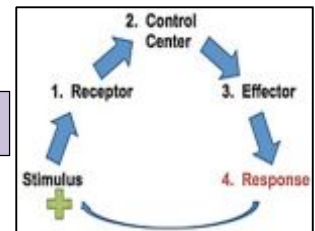


Figure-18: Positive feedback mechanism.

Sleep cycle

Applied note: A young adult typically passes through stages 1 and 2, and spends 70–100 min in stages 3 and 4. Sleep then lightens, and a REM period follows. This cycle repeats at 90-min intervals throughout the night. REM sleep occupies 50% of total sleep time in full-term neonates; this proportion declines rapidly and plateaus at about 25% until it falls further in old age.

Figure-19: Sleep cycle.

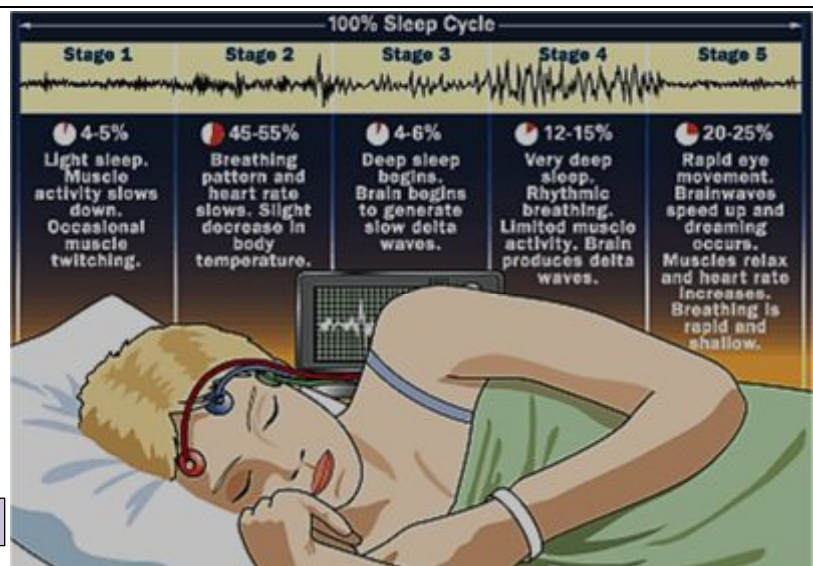


Table-4: Sleep physiology.

Disorders of sleep: (See table-5 and figure 20)

A. Snoring	☞ Airway passage is partially blocked and air from the nose (or throat) passes around the blockage causing throat structures to vibrate against each other making the snoring noise .
B. Sleep apnea	☞ It may be obstructive (as in obesity) or central (inhibition of respiratory center). ☞ Partial or complete obstruction in the airway leading to pauses in breathing. The brain is alerted and the person resumes breathing. ☞ It is the most common cause of daytime sleepiness due to fragmented sleep at night. ☞ Breathing ceases for more than 10 sec during frequent episodes of obstruction of the upper airway (especially the pharynx) due to reduction in muscle tone. ☞ The apnea causes brief arousals from sleep in order to reestablish upper airway tone. Figure-20: Sleep apnea.
C. Insomnia	☞ Difficulty initiating or maintaining sleep.
D. Narcolepsy	☞ It is a chronic neurological disorder caused by the brain's inability to regulate sleep-wake cycles normally. ☞ There is a sudden loss of voluntary muscle tone (cataplexy), an eventual irresistible urge to sleep during daytime, and possibly also brief episodes of total paralysis at the beginning or end of sleep. ☞ It is characterized by a sudden onset of REM sleep, unlike normal sleep which begins with non-REM (slow-wave) sleep.
E. Restless legs syndrome	☞ Unpleasant, tingling, or creepy-crawly feelings in the legs with an irresistible urge to move .
F. Parasomnias	☞ They are sleep disorders associated with arousal from non-REM and REM sleep. ☞ They include: 1. Sleep walking (somnambulism): episodes of sleep walking are more common in children than in adults and occur predominantly in males. They may last <i>several minutes</i>. Somnambulists walk with their eyes open and avoid obstacles, but when awakened they <i>cannot recall the episodes</i>. It occurs during NREM sleep. 2. Bed-wetting (nocturnal enuresis). 3. Night (sleep) terrors (pavor nocturnus): feeling of terror or dread. It occurs during NREM sleep. 4. Night mares: bad dreams cause feelings of horror or fear. It occurs during REM sleep. NB: Sleep disorders are classified into dysomnias (as insomnia, narcolepsy and sleep apnea) and parasomnias (as night terrors, night mares and somnambulism).

Table-5: Disorders of sleep.

Case discussion:

Case:

An 8-year-old boy is brought into the emergency room by his mother after he awoke from sleep with right-mouth tingling followed by 1 minute of right facial twitching and drooling. During this spell, he had difficulty speaking. His mother says that when he was 1 year old he had an episode of generalized shaking while ill with a viral gastroenteritis with a fever of 38.9°C. On further questioning, she recalls that on one occasion when he was 4 years old, he awoke having urinated in his bed and bitten his tongue, and was lethargic for half a day. The family history is significant for childhood seizures in his father. The patient has otherwise developed normally, scoring A's in the gifted and talented school program. He has not had any recent fevers or head trauma. On examination, he appears slightly tired but otherwise back to his baseline. His temperature is 36.7°C; heart rate 80 beats/min; respiration rate 18 breaths/min and blood pressure 90/60 mmHg.

Discussion of the case:

In the presented case, this 8-year-old boy experienced a characteristic nocturnal seizure with right facial twitching and drooling. His consciousness was preserved. Before 5 years of age, patients can also have secondary generalization, with spread

from the facial twitching to involve whole body tonic-clonic activity with incontinence, tongue-biting, and postictal confusion. The patient also has a history of a febrile seizure and family history of childhood seizures, therefore this presentation is highly suggestive of benign rolandic epilepsy, which has an autosomal dominant pattern of inheritance.

Seizure: A single event characterized by an abnormal excessive synchronized discharge of cortical neurons. Between 7–10% of people will have a seizure at some point in their lives.

Epilepsy: The tendency to have recurrent seizures with stereotyped cognitive or physical manifestations. The lifetime risk of epilepsy is 3%.

Status epilepticus is defined as a seizure lasting longer than 30 minutes or multiple seizures in succession without return to baseline alertness; this is a neurologic emergency because of the potential to cause permanent brain injury and complications such as hypoxia and autonomic instability.

Febrile seizures are very common, occurring in 3–5% of children between 6 months and 3 years of age during illness with high fevers, and should disappear by 5 years of age.

Up to 50% of epilepsy patients will have a normal first EEG. MRI should be performed particularly with an abnormal developmental history or physical examination.

Summary and references:

Summary:	References:
☞ Electroencephalogram is a diagram represents the recording of the electrical activity (potential variations) that occurs in the brain in different conditions. ☞ Electrocorticogram is obtained if we apply the recording electrodes directly on the brain during neurosurgical operations. ☞ Alpha rhythm in EEG is recorded in adults during complete rest with closed eyes (but, awake) i.e. physical and mental rest. ☞ Delta rhythm in EEG is recorded in deep sleep. ☞ In alpha block (dysynchronization), alpha rhythm is replaced by beta wave (rhythm) during alert conditions and solving mathematical problems. ☞ Sleep is a state of transient loss of consciousness from which person can be aroused by normal non harmful stimuli. ☞ Slow wave sleep (SWS) occupies 75% of sleep time. ☞ Prolonged wakefulness causes progressive accumulation of many metabolites (as muramyl peptide and serotonin) in brainstem and CSF, that when reach a certain concentration they produce sleep (metabolic theory). ☞ When the sleeping centers are not active, the reticular activating system stimulates the cerebral cortex which in turn activates the reticular formation that reactivates the cerebral cortex and so...on. This keeps the state of wakefulness till it becomes fatigued or the sleeping centers become active (positive feedback theory). ☞ Somnambulism means sleep walking. Somnambulists walk with their eyes open and avoid obstacles, but when awakened they cannot recall the episodes.	1. Dr Khaled Abulfadle physiology site, Link: khafadle.ahlamontada.net 2. Ganong's review of medical physiology, 24th Edition, 2012. 3. Guyton & Hall textbook of medical physiology 12th edition. 4. Medical physiology, principles for clinical medicine, 4th edition. 5. Color atlas of physiology, 6th edition. 6. Human Physiology, integrated approach, by Dee Unglaub Silverthorn, 5th edition, 2010. 7. Physiology by Linda S Costanzo, 5th edition, 2014. 8. Case files neurology, Lange series, 2008. 9. Essentials of medical physiology by K Sembulingam, 6th edition, 2012. 10. Medical physiology, A systems approach, by Hershel Raff, 2011. 11. Human physiology, by Wikibooks contributors, 2007.

Examples of self-assessment questions:

SEQs:

- 1-Define electroencephalogram (EEG), alpha block and rapid eye movement sleep?
- 2-Outline basic waves of electroencephalogram (EEG)?
- 3-Mention types of epilepsy?
- 4-Discuss functions of reticular formation?
- 5-What is the importance of electroencephalogram (EEG)?
- 6-Tabulate differences between rapid eye movement (REM) sleep and slow wave sleep (SWS)?
- 7-Describe possible mechanisms of sleep?
- 8-List 5 sleep disorders?

MCQs:

- 9-How many hours do the adult persons need to sleep every 24 hours?
 - A. 2.
 - B. 5.
 - C. 8.
 - D. 11.
 - E. 14.
- 10-Sleep deprivation causes which of the following?
 - A. Psychosis.
 - B. Polyphagia.
 - C. Calmness.
 - D. Parasympathetic stimulation.
 - E. Increased mental activity.

- 11-Which of the following electroencephalogram (EEG) rhythm is recorded in adults during complete rest with closed eyes?
 - A. Delta.
 - B. Alpha.
 - C. Beta.
 - D. Theta.
 - E. Gamma.
- 12-Which of the following sleep disorder is a meaning for somnambulism?
 - A. Insomnia.
 - B. Hypersomnia.
 - C. Bed wetting.
 - D. Sleep walking.
 - E. Snoring.
- 13-Which of the following sleep disorder represents nocturnal enuresis?
 - A. Insomnia.
 - B. Hypersomnia.
 - C. Bed wetting.
 - D. Sleep walking.
 - E. Snoring.
- 14-Which of the following electroencephalogram wave is recorded in deep sleep?
 - A. Alpha.
 - B. Beta.
 - C. Theta.
 - D. Delta.
 - E. Gamma.

15-Which of the following electroencephalogram wave is recorded in the normal alert adults?

- A. Alpha.
- B. Beta.
- C. Theta.
- D. Delta.
- E. Gamma.

16-Which of the following is a feature of rapid eye movement sleep?

- A. Muscle tone is stimulated.
- B. No eye movements occur.
- C. It occupies 75% of sleep time.
- D. Person is easy to be aroused.
- E. Brain is highly active.

17-Which one of the following is a character of reticular activating system?

- A. It is a part of spinal cord interneurons.
- B. It arises from excitatory reticular formation.
- C. Its fibers pass mainly to PVLN of thalamus.
- D. Its fibers relay into localized areas in cerebral cortex.
- E. Its stimulation causes sleep.

18-Which type of epilepsy shows frequently urination and defecation during its attack?

- A. Grand mal.
- B. Petit mal.
- C. Jacksonian.
- D. Absence.
- E. Psychomotor.

19-Which type of epilepsy is a synonym to absence epilepsy?

- A. Grand mal.
- B. Petit mal.
- C. Jacksonian.
- D. Focal.
- E. Psychomotor.

20-Which type of epilepsy shows a spike and dome pattern in electroencephalogram?

- A. Focal.
- B. Grand mal.
- C. Jacksonian.
- D. Petit mal.
- E. Psychomotor.

21-Which of the following is a feature of excitatory reticular formation?

- A. Present in the medulla oblongata.
- B. Has its own intrinsic activity.
- C. Gives rise to lateral reticulo-spinal tract.
- D. Inhibited by basal ganglia.
- E. Decreases muscle tone.

22-Which one of the following represents a state of a transient loss of consciousness from which the person can be aroused by normal non harmful stimuli?

- A. Coma.
- B. Epilepsy.
- C. Sleep.
- D. Seizure.
- E. Tetany.

23-Which of the following EEG wave is recorded in slow wave sleep?

- A. Delta.
- B. Beta.
- C. Theta.
- D. Alpha.
- E. Gamma.

24-Which one of the following is the sleep factor?

- A. Dopamine.
- B. Amphetamine.
- C. Adrenaline.
- D. Strychnine.
- E. Serotonin.

25-Which wave of EEG is characteristically recorded from geniuses?

- A. Alpha.
- B. Beta.
- C. Theta.
- D. Delta.
- E. Gamma.

26-Which of the following EEG rhythm represents the dominant one observed with electrodes over the occipital lobes, in a healthy, alert adult sitting with his eyes closed?

- A. Delta (0.5–4 Hz).
- B. Theta (4–7 Hz).
- C. Alpha (8–13 Hz).
- D. Beta (18–30 Hz).
- E. Gamma (30–80 Hz).

27-Which of the following is a feature of gamma rhythm in EEG?

- A. It is characteristic of seizure activity.
- B. It is generated in the hippocampus.
- C. It is seen in an individual who is awake but not focused.
- D. It is of a high rhythm (30–80 Hz).
- E. It is independent of thalamocortical loops.

28-K complexes in electroencephalogram (EEG) is recorded in which stage of sleep?

- A. 1.
- B. 2.
- C. 3.
- D. 4.
- E. 5.

MEQs:

29-A 55-year-old woman reported that for the previous 6 years she had been having episodes at night where she had dreams that often had a fearful content. According to her husband, some of these were associated with her kicking, punching, shouting and making noises. She had had three episodes where she had injured herself and, following these, she recounted the dreams to her husband.

- a. Outline possible mechanisms of sleep?
- b. List five features of non-rapid eye movement sleep?

30-A 60-year-old male experienced numerous episodes of a sudden loss of muscle tone and an irresistible urge to sleep in the middle of the afternoon. He was diagnosed with narcolepsy.

- a. Mention 3 other sleep disorders?
- b. List 3 features of REM sleep?

Key answer:	9-C.	10-A.	11-B.	12-D.	13-C.	14-D.	15-B.	16-E.	17-B.	18-A.	19-B.	20-D.
	21-B.	22-C.	23-A.	24-E.	25-E.	26-C.	27-D.	28-B.				